CRITIQUE SUMMARY

Critique No.: CH-BH-BNL-AGS-2000-0004 **Date of Critique**: 10-5-00, 10-9-00, 10-18-00

Critique Leader: Ed Lessard

Meeting Participants: 10-5-00: Ed Sierra, Tom Nehring, Vincent LoDestro, Brian Briscoe, Jim Wright, Leo Somma, John Read, Jim Alessi, P. K. Feng, Peter Kelley, Joe Curtiss, Ray Karol, Ed Lessard. **10-9-00:** Vincent LoDestro, Joe Curtiss, Ed Sierra, Brian Briscoe, Tom Nehring, Steve Waski, John Read, Jim Alessi, Ed Lessard. **10-18-00:** Jim Alessi, Ed Sierra, Leo Somma, Jim Wright, Tom Nehring, Joe Curtiss, John Read, Steve Waski, Dave Passarello, Ray Karol, Peter Kelley, Joe Levesque.

Brief Event Description:

At 0050 on 10/4/00, a Collider-Accelerator Support (CAS) Watch entered Building 930 for a routine check of equipment running at Linac. He found a smoke-filled building and pulled a fire-alarm box. He went outside and noticed no alarms nor did the Fire Department respond. He went back into Linac Control Room in Building 930, a location where he noticed no smoke and called extension 911. The on-duty Fire/Rescue Officer told the CAS Watch to pull another fire-alarm box and to go out to the road to guide the responding unit. The CAS Watch pulled a box near the Linac Control Room and left the building. This pull box caused the discharge of the halon fire-protection system and activated local audible alarms, however this pull box also failed to alert the Fire Department. First-arriving Fire Department staff found a moderate smoke condition. They searched the facility but did not find the source of smoke. Linac personnel arriving at 0120 found a damaged Motor Control Center (MCC) with burned material in front of the MCC panels. The fire burned itself out, and the smoke was vented without incident. The area has a sprinkler protection system and a heat detection system, but the heat from the fire was not great enough to activate these systems. No radioactive materials were involved.

The Collider-Accelerator complex is in a shutdown mode and there is no programmatic impact. A subsystem of the Linac was being used to help support an experiment for the Spallation Neutron Source (SNS) Project. The damaged compartment in the MCC was devoted to powering water pumps.

The investigation showed an electric short on the line side of one of the MCC compartments, which triggered the following chain of events:

1. A 12-gallon size plastic bag of aluminum foil and paper wipes inadvertently left in front of the Motor Control Center was ignited.
2. The plastic bag fire resulted in damage to two additional electrical compartments on the Motor Control Center.
3. Local fire alarm pull boxes failed to:
   - Alarm locally
   - Signal the on-site Fire Department
4. Further attempts by the CAS Watch to sound the building alarms resulted in 1253 pounds of halon being unnecessarily discharged.

Reference Materials (e.g., work procedures, written statements, etc.):

1. CH-BH-BNL-AGS-2000-0004, “Electrical Overload at Motor Control Center.”
2. Plant Engineering Division’s PM Records for Fire Alarm Testing, PM Work Orders P074953, P077820, P081236, P084141, P085658, P088230, and P074952
3. Photographs of damaged Motor Control Center
4. NFPA 70B, Recommended Practice for Electrical Equipment Maintenance
5. DOE-STD-1050-93, Guideline to Good Practices for Planning, Scheduling, and Coordination of Maintenance at DOE Nuclear Facilities
6. DOE-STD-1051-93, Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities

RELEVANT FACTS AND DATA ASSOCIATED WITH THE EVENT
(e.g. event chronology, work activities at variance with governing documentation, etc.)

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See attached Events and Causal Factors Chart.

ANALYSIS OF RELEVANT FACTS AND DATA:

The order of probable causal factors does not indicate significance.

Probable Causal Factors:

For electrical failure:

The cause of the electrical failure was likely a high resistance in the supply from the buss. The resulting heat from the resistance most likely damaged the insulation of the conductors within the cabinet. Since there was no indication of arcing to compartment walls, a phase-to-phase short would have occurred and fuses destroyed. The resulting arc over would have over-pressurized the compartment with the flash. There were bulges in the door indicating overpressure. The shower of sparks would have ignited the plastic bag directly under the compartment.

The trash-bag fire as the initiating event was considered. The fire starting in the plastic trash bag was less likely for the following reasons:

1. An ignition source could not be found in the plastic bag debris, which was fairly intact.
2. The most heavily damaged compartment is the second level compartment, not the first compartment adjacent to the plastic bag.
3. The plastic bag contained minimal combustibles and is considered an unlikely ignition source for the heavy and dense plastic handle on the front of the second level compartment. This handle needed to be ignited to provide a path into the heavily damaged second level compartment.

A small animal such as a mouse reaching across phases and causing a short circuit in the second-level compartment was possible. However, it was ruled out since animal remains were not found among the debris.

An overheating connection can be spotted during maintenance, but if left uncorrected then over time the condition will worsen and eventually lead to deterioration of insulation and a short circuit with resultant electric arc. Short-circuit current was limited to about 30,000 amps for this MCC by upstream over-current protection.

We conclude that the energy in the resultant arc blast destroyed the wiring and fuses within the middle compartment, and ignited a bag of trash inadvertently placed against the metal cover of the lowest compartment. We conclude the source of the short circuit middle compartment was likely due to insulation damage from an overheating connection.

The MCC was rewired in the late 1970's or early 1980's. The local motor starters in a number of MCC compartments were by-passed and simply used as fused disconnects. At that time, motor starters were installed closer to the equipment being powered. A water pump on an experimental cooling system was drawing power through the fused-disconnect in the middle compartment at the time of failure. There was no damage to the water pump or motor starter.

Preventive maintenance (PM) on these MCC compartments was not likely to have been performed since 1995. The Department point-of-contact who routinely scheduled PM retired in September 1994, and several personnel changes at this position have occurred since then. In recent years, the time set aside for PM has been shortened and the schedule for shutdowns has changed to accommodate the running of experiments. PM has been infrequent since mid-1980 due to the increased number of similar installations to maintain at the Laboratory, which in turn was due to the construction of the Relativistic Heavy Ion Collider (RHIC). At the same time, there was a decrease in labor for this type of maintenance work. Before mid-1980, PM on MCCs was done every two to three years. The Department point-of-contact would call in electricians whenever the line side was shut down for PM at the substations. Typical PM consists of racking out the MCC compartments and visually inspecting for discoloration, excessive pitting, damaged insulation or evidence of welding, which are indicative of excessive heat. In addition, all connections were checked tight.

The cause of the event was a poor connection. Likely contributing factors are:

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1. An increase in the number of electrical distribution systems on which to perform PM.
2. Retirement of staff.
3. A decrease in the PM staff.
4. Fewer opportunities for PM.
5. Lack of a formal PM policy for programmatic electrical distribution equipment at C-AD.
6. Lack of a coordinated system between the HENP and the F&O Directorates to schedule PM.

For alarm panel failure:

A 2-amp fuse blew on the fire alarm panel (930-FAP150). The cause of the blown fuse is not clear. It may have been blown since the last time PM was performed, or blew coincident with this event. With this particular fuse blown, it puts the fire alarm panel in a "sleeper" mode. That is, for this type of failure, there is a loss of all AC and backup DC power to a portion of FAP150. This results in loss of both local and remote "trouble" indication to the Fire Department, and in addition, the local pull stations will not transmit signals to the Fire Department. A white local trouble light on FAP150 did work, but the associated panel buzzer failed or personnel entering the scene did not hear it. This type of failure is inherent in this particular fire alarm panel; a panel that dates back to about 1967. Similar fuse failures in FAP150 were not recorded during performance of previous PMs.

The fact that this fuse may have been blown for some time did focus the team on the adequacy and performance of fire alarm PM. Completion of the quarterly, semi-annual or annual PMs would likely have found this blown fuse. We note that quarterly, semi-annual and annual PMs consist of different tests that taken together constitute complete testing. The investigation team's review of the PM history of FACP150 raised concern regarding deferred PM. It was learned that Departments are not notified for concurrence and/or approval of deferred or missed fire alarm PM.

The last annual PM was completed on July 22, 1999. A quarterly test was completed on December 13, 1999. The next quarterly should have been completed in April 2000. However, since the annual PM was approaching its next normal due date, Plant Engineering Division decided to perform the tests associated with April 2000 quarterly PM during the annual PM on FACP150 in May 2000. As a further complication, the annual PM was deferred due to accelerator operation and was not performed as of October 4, 2000, the date of the event. This deferral caused the performance of the quarterly tests in April 2000 to be missed. The next quarterly PM was performed on July 17, 2000, at which time it was likely a blown fuse would have been detected had it existed. In summary, the tests associated with quarterly PM scheduled for April 2000 were missed, and those associated with annual PM scheduled for May 2000 were months overdue.

PM tasks were reported to be missed by Plant Engineering due to increased experiment running at the Collider-Accelerator complex and due to increased PM tasks following the construction of the Relativistic Heavy Ion Collider (RHIC), which reduced the availability of electricians and fire-alarm technicians. In addition, there was a lack of coordination between shutdown-schedules driven by the HENP and RHIC Project Directorates and PM-schedules driven by the F&O Directorate.

Recommended Corrective Actions (Action due dates are to be found in CH-BH-BNL-AGS-2000-0004):

For the electric short in the MCC compartment:

1. C-A Department should schedule preventive maintenance (PM) on all the MCC compartments in programmatic critical facilities.
2. C-A Department should develop a procedure, which is based on NFPA 70B and similar documents mentioned in the references section of this report, and set up PM tasks for electrical distribution equipment. Following procedure development, C-A Department should review its facilities and schedule PM for all its programmatic electrical distribution equipment.
3. Improve coordination of shutdown and maintenance schedules between the HENP Directorate and the F&O Directorate. Shutdown schedules must be discussed between C-A and PE personnel with as much notice as possible. Schedules will need to be adjusted to suit programmatic operating schedules, and for times when PE places high-voltage equipment in shutdown status so that C-A Department can request PM services on programmatic equipment at the same time. For itself, C-A Department Building Managers should track and report to C-A management missed PM on electrical distribution equipment.

4. Plant Engineering shall conduct an evaluation of their site-wide electrical distribution system maintenance program. The evaluation shall check for robust coverage and timely completion of prescribed maintenance.

For alarm panel failure:

1. The BNL Deputy Director for Operations should reevaluate the Activity Data Sheet (ADS) identifying the need to upgrade approximately 60 fire alarm panels reported to be on-site with similar age and similar single-point failure design deficiency. The interim fix used at FAP150 to remote an alert on a failed blown 2-amp fuse solves only one of this panel's known design deficiencies, and FACP150 is reported to be different from other panels on-site.
2. The Plant Engineering Division Head should charge a Fire Protection Planning Team that has site-wide representation to analyze fire-alarm system upgrades for the site and resolve on-going issues. Some issues that should be addressed by the Plant Engineering Division Head are:
    a. Recommend methods to notify customers (Departments, Divisions) and appropriate Plant Engineering Management of overdue PM on fire-alarm systems.
    b. Recommend the process by which the extension of a PM schedule is authorized.
    c. Review site-wide labeling of fire alarm and fire-protection systems such as halon and recommend uniform site-wide labeling schemes.
    d. Review and recommend a formal process by which changes to fire alarm system wiring and/or logic are authorized.
    e. Recommend goals to achieve for completing PM similar to the goal recently adopted and achieved for training completions at BNL.
3. C-A and PE should work to improve coordination of shutdown and maintenance schedules between the HENP Directorate and the F&O Directorate. For itself, C-A Building Managers should track and report missed fire alarm maintenance to C-A Department management.

Recommended Lessons Learned:

An awareness level program should be instituted to remind BNL staff to check areas near electrical distribution equipment for any nearby materials and to remove these materials to safer locations. Boundary locations should be clearly defined. BNL staff should be made aware of requirements for clear zones in front of electrical distribution equipment and why these areas must be kept free of materials.

Signature:

Edward T. Lessard (Signature on File)	10-31-00
Critique Leader	Date

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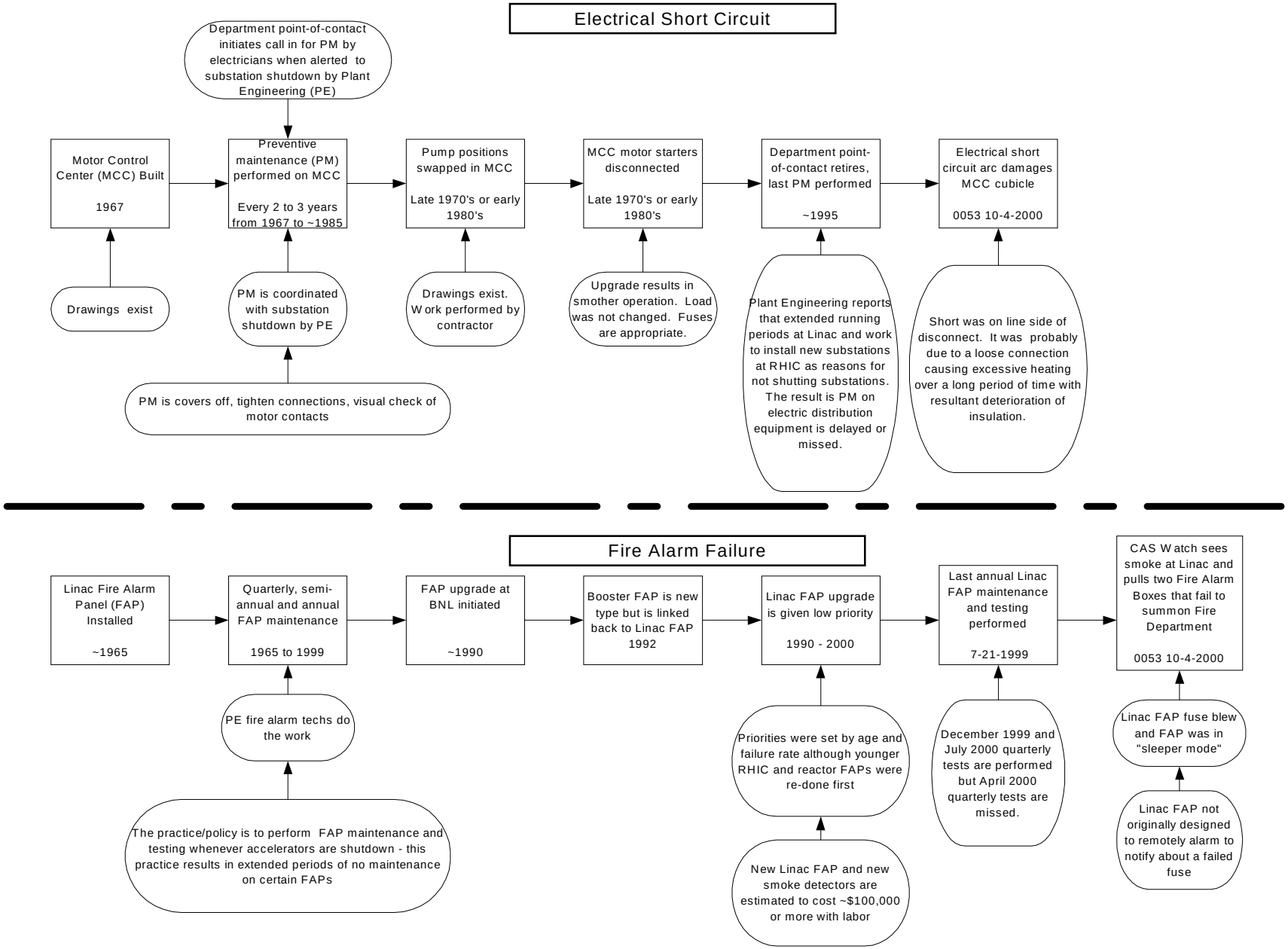

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